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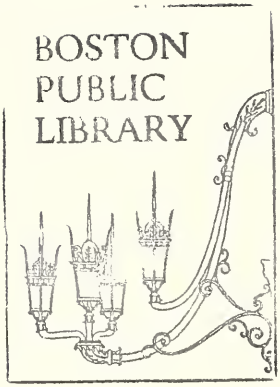
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MEMORANDUM

TO: Eric Schmidt

FROM: Antonio Fiol-Silva

RE: Central Artery/Pedestrian-Level Wind Impacts

DATE: September 11, 1990

During the course of Central Artery discussions concern has been raised by several people about the potential for adverse pedestrian level wind impacts throughout the corridor, due to the open-space nature of the proposed plan. This concern has given rise to suggestions of placing buildings on several of the open space parcels as a method of wind mitigation.

On several occasions this view has been articulated by Skip Smallridge of Wallace Floyd and Associates, who referred to studies done by the state for the purpose of studying the vent structures as indicating the incidence of high wind speed levels along the corridor. These studies however, focused on the dispersion of tunnel exhausts through vent stacks as high as 240 ft. (Edison site-vent building no. 3) and do not in any way deal with ground conditions.

Some ground level data is available through the Final Environmental Impact Reports (FEIR's) of eight high-rise projects located along the central artery corridor. This data, covering some 98 points along the corridor, can be useful to get a sense of what pedestrian-level wind impacts might be in the completed corridor. However further studies accounting for future planned conditions are needed to obtain a clearer picture.

Heat sensor locations from the quantitative wind tunnel tests of the eight FEIR's are plotted in figures 1-3 and described in table 1. This is done for easy reference and one has to remember that they are the results of 8 separate and independent tests. Those locations that exceed the BRA design criteria limiting effective gust velocities to < 31 mph. are highlighted. In this table, Mean wind velocity when given, can be checked against Melbourne's Criteria ratings (for average hourly pedestrian winds) to determine pedestrian comfort for a variety of activities (table 2).

According to the FEIR's data we note that while microclimactic conditions at pedestrian level vary greatly, generally slower winds speeds occur at ground level due to existing surface "buffers" such as trees, canopies and lower building masses. In the new rebuilt corridor one could assume that carefully considered plantings and lower structures would further improve conditions. The enclosed appendix suggests ways in which this could be achieved.

include

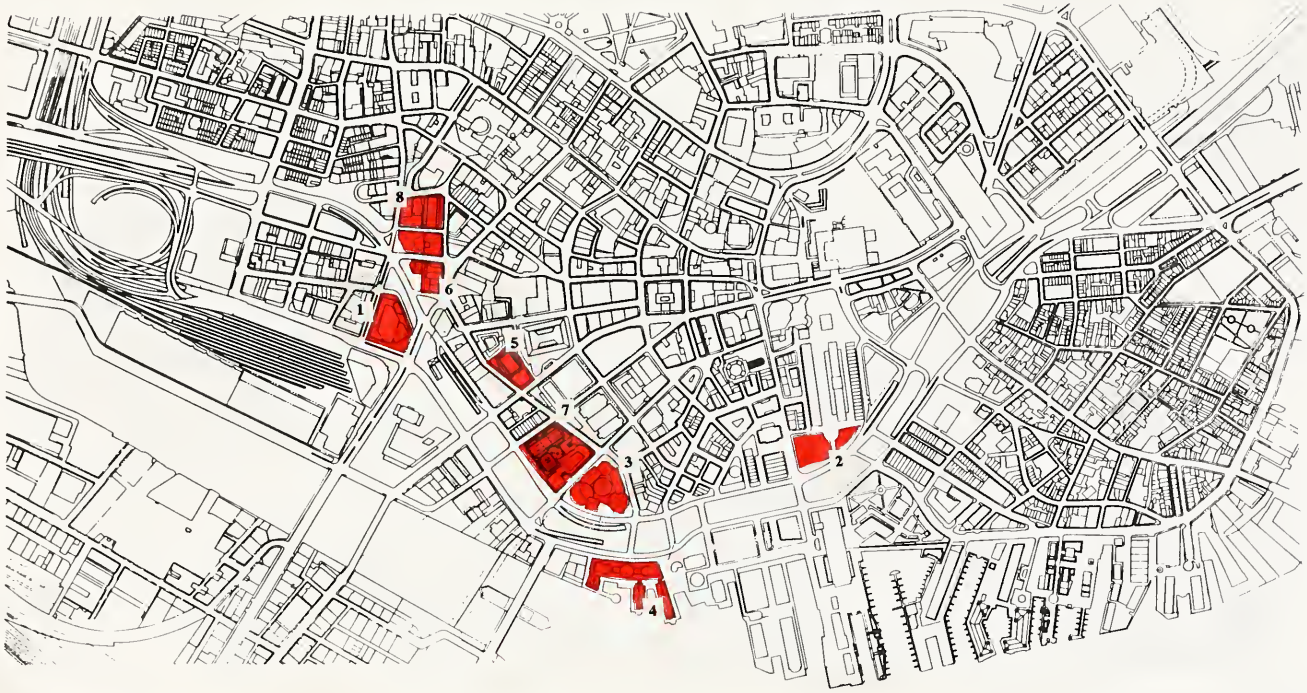
Of particular interest is the data presented in the International Place FEIR which ran qualitative wind tunnel tests (smoke trace) on two configurations: a). a completed project fronting on an open corridor (figure 9c) and, b). a completed project fronting three 140 foot high buildings over the Artery. (figure (9 e). Though oddly shaped, the 140 foot high buildings depicted in the study represent those 10 story office buildings which could be built according to the informal rule-of-thumb engineering constraints for buildings over the air-rights parcels. Studies of these scenarios show that the placing of buildings in the corridor tended to worsen pedestrian-level wind impacts, for it produced wind channeling conditions that drastically increased wind speeds along the two separated streets.

The information seems to suggest that an entirely open corridor with ground surface buffers (trees, etc) may best serve to ameliorate adverse pedestrian-level wind impacts. As different building locations and configurations are considered for buildings along the corridor, the probable microclimatic- conditions for each alternative configuration will vary greatly, it is for that reason that further wind testing should be only done only after fairly well defined plans are prepared prior to further testing.

cc. S.C.
D.K.
T.C.
L.B.
R.B.

WIND IMPACTS FROM FEIR'S

CENTRAL ARTERY CORRIDOR PROJECT



1. ONE DEWEY SQ. (DS) - 1981
2. MARKET PLACE CENTER (MC) - 1982
3. INTERNATIONAL PLACE (IP) - 1984
4. ROWES WHARF (RW) - 1984
5. 150 FEDERAL STREET (FS) - 1985
6. 125 SUMMER STREET (SS) - 1987
7. 125 HIGH STREET (HS) - 1987
8. ONE LINCOLN STREET (LS) - 1989

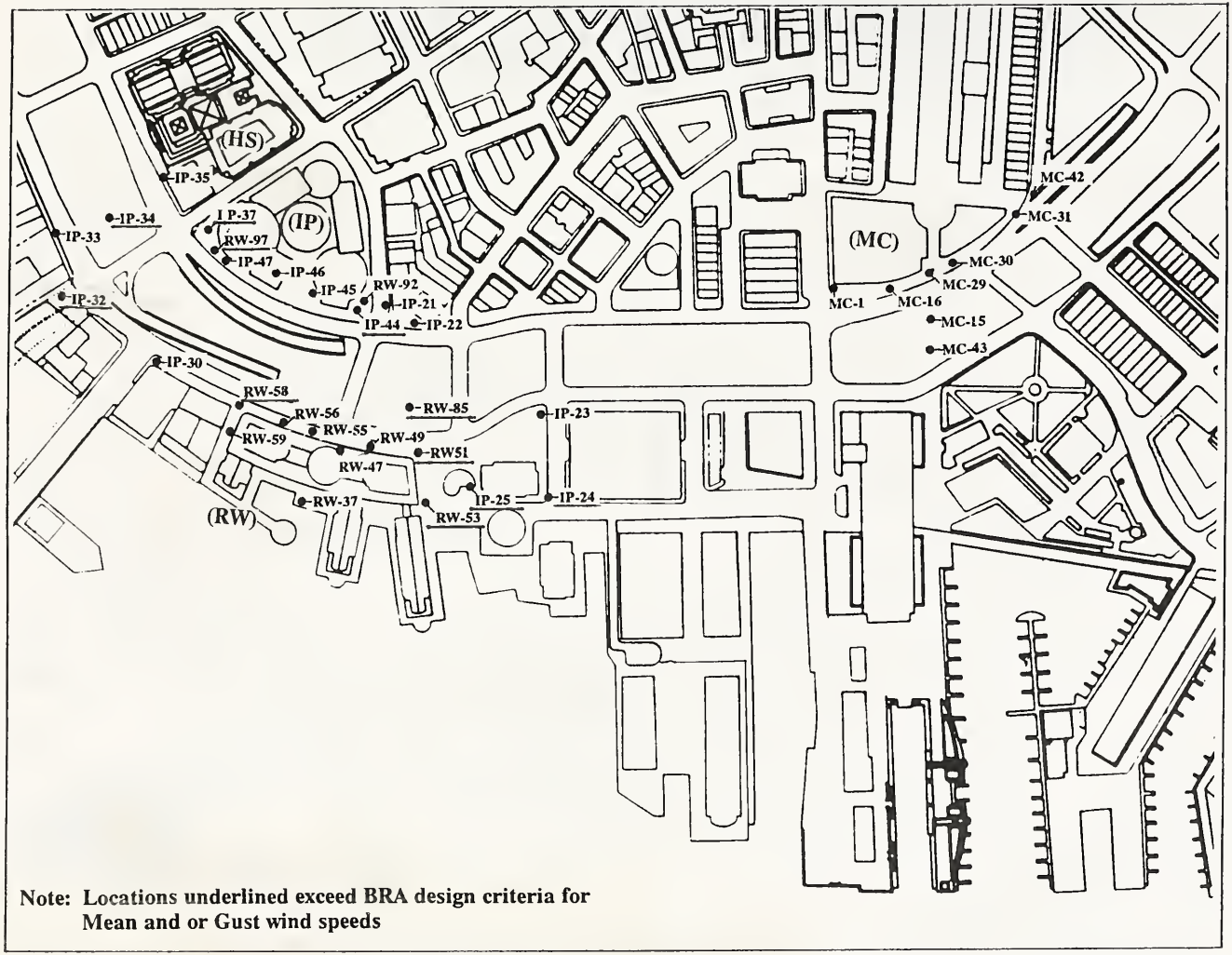


Figure 1 – Wind Speed Mesurement Locations

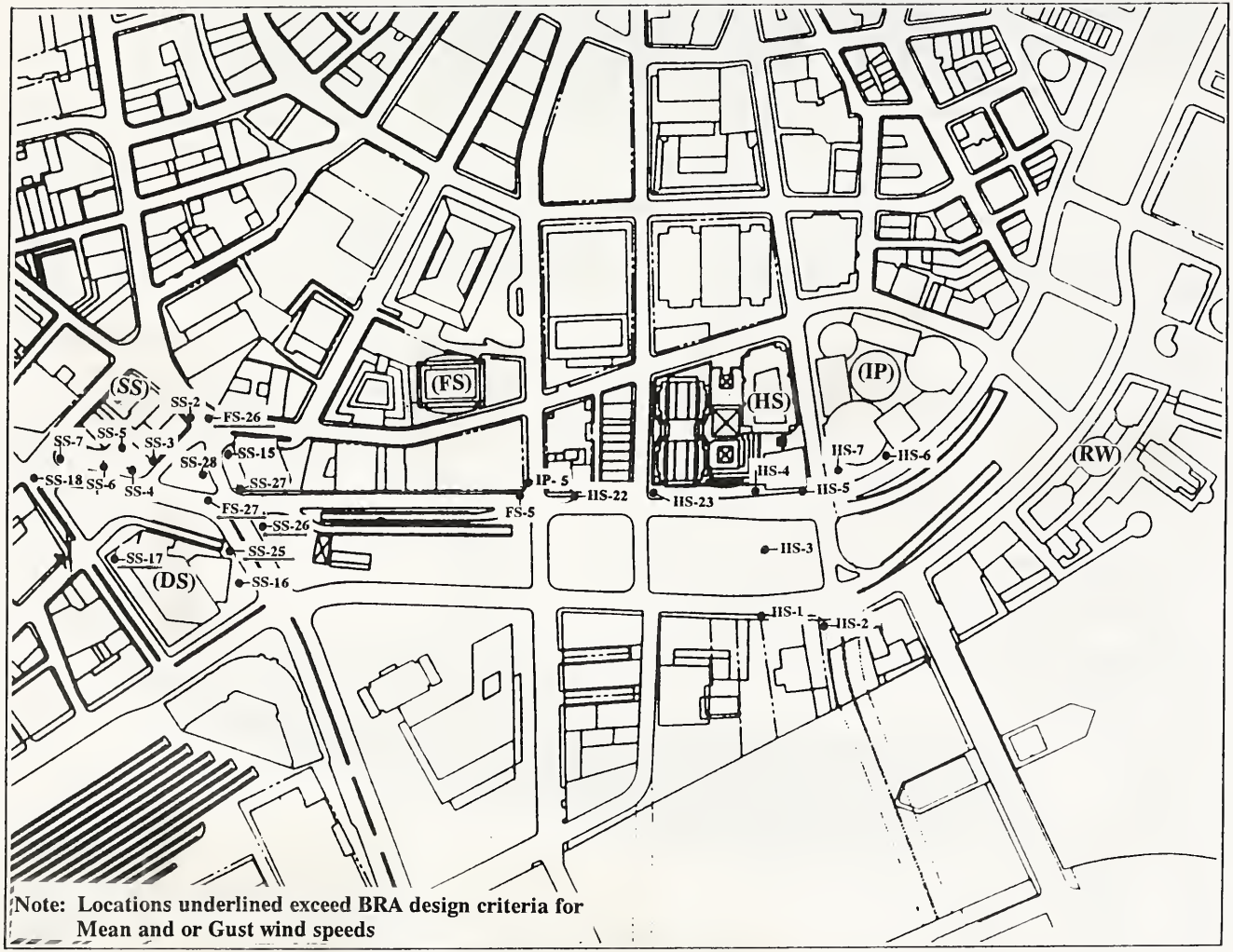


Figure 2 — Wind Speed Mesurement Locations

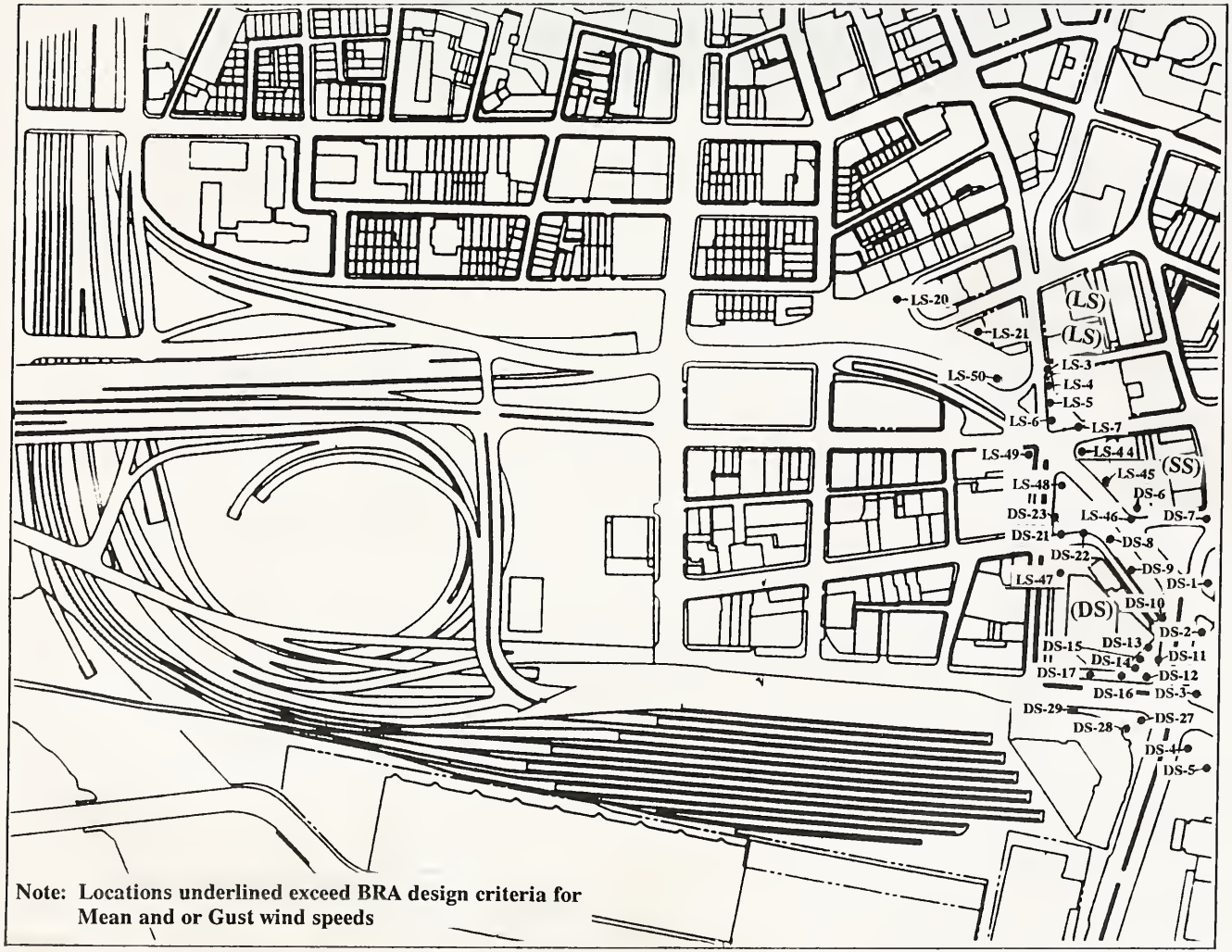


Figure 3 – Wind Speed Mesurement Locations

TABLE 1

WIND SPEED MEASUREMENTS

1. (DS) ONE DEWEY SQUARE - 1981

Location	Mean Wind Velocity* (MPH)	Gusts Wind Velocity** (MPH)
DS-1	N/A	13.4
DS-2		20.4
DS-3		20.0
DS-4		13.4
DS-5		11.1
DS-6		16.1
DS-7		12.4
DS-8		16.5
DS-9		18.0
DS-10		18.4
DS-11		21.1
DS-12		16.1
DS-13		17.2
DS-14		18.9
DS-15		9.7
DS-16		10.2
DS-17		23.1
DS-21		20.8
DS-22		12.5
DS-23		17.6
DS-27		25.1
DS-28		23.9
DS-29		29.6

2. (MC) MARKETPLACE CENTER - 1982

Location	Mean Wind Velocity* (MPH)	Gust Wind Velocity** (MPH)
MC-1	15.3	30.4
MC-15	16.6	27.3
MC-16	18.3	29.5
MC-29	19.6	28.3
MC-30	11.0	21.5
MC-31	19.0	28.8
MC-42	16.7	27.3
MC-43	13.8	24.9

3. (1P) INTERNATIONAL PLACE - 1984

Location	Mean Wind Velocity* (MPH)	Gust Wind Velocity** (MPH)
1P-5	19	26
1P-21	16	23
1P-22	14	22
1P-23	15	25
1P-24	29	38
1P-25	27	38
1P-30	16	24
1P-32	37	53
1P-33	22	31
1P-34	21	32
1P-35	13	20
1P-37	26	34
1P-44	23	31
1P-45	20	31
1P-46	21	30
1P-47	21	30

4. (RW) Rowes Wharf - 1984

Location	Mean Wind Velocity* (MPH)	Gust Wind Velocity ** (MPH)
RW-37	N/A	24
RW-47		30
RW-49		28
RW-51		34
RW-53		32
RW-55		29
RW-56		28
RW-58		32
RW-59		26
RW-85		32
RW-92		26
RW-97		36

5. (FS)150 Federal Street - 1985

Location	Mean Wind Velocity* (MPH)	Gust Wind Velocity** (MPH)
FS-27	23.6	26.32
FS-5	18.9	22.28
FS-26	31.95	36.45

6. (SS) 125 Summer Street - 1987

Location	Mean Wind Velocity* (MPH)	Gust Wind Velocity** (MPH)
SS-2	16.7	26.1
SS-3	15.7	25.0
SS-4	14.9	22.0
SS-5	9.6	16.0
SS-6	15.7	24.4
SS-7	18.7	26.3
SS-15	16.4	25.9
SS-16	20.3	30.5
SS-17	24.1	34.2
SS-18	15.4	24.0
SS-25	28.1	36.9
SS-26	27.2	37.2
SS-27	26.3	35.4
SS-28	18.8	30.5

7. (HS) 25 High Street - 1987

Location	Mean Wind Velocity* (MPH)	Gust Wind Velocity** (MPH)
HS-1	14.3	21.7
HS-2	15.1	19.8
HS-3	17.3	22.9
HS-4	10.1	16.2
HS-5	18.3	24.7
HS-6	13.6	19.3
HS-7	19.1	24.2
HS-22	12.4	18.6
HS-23	18.9	23.1

8. (LS) One Lincoln Street - 1987

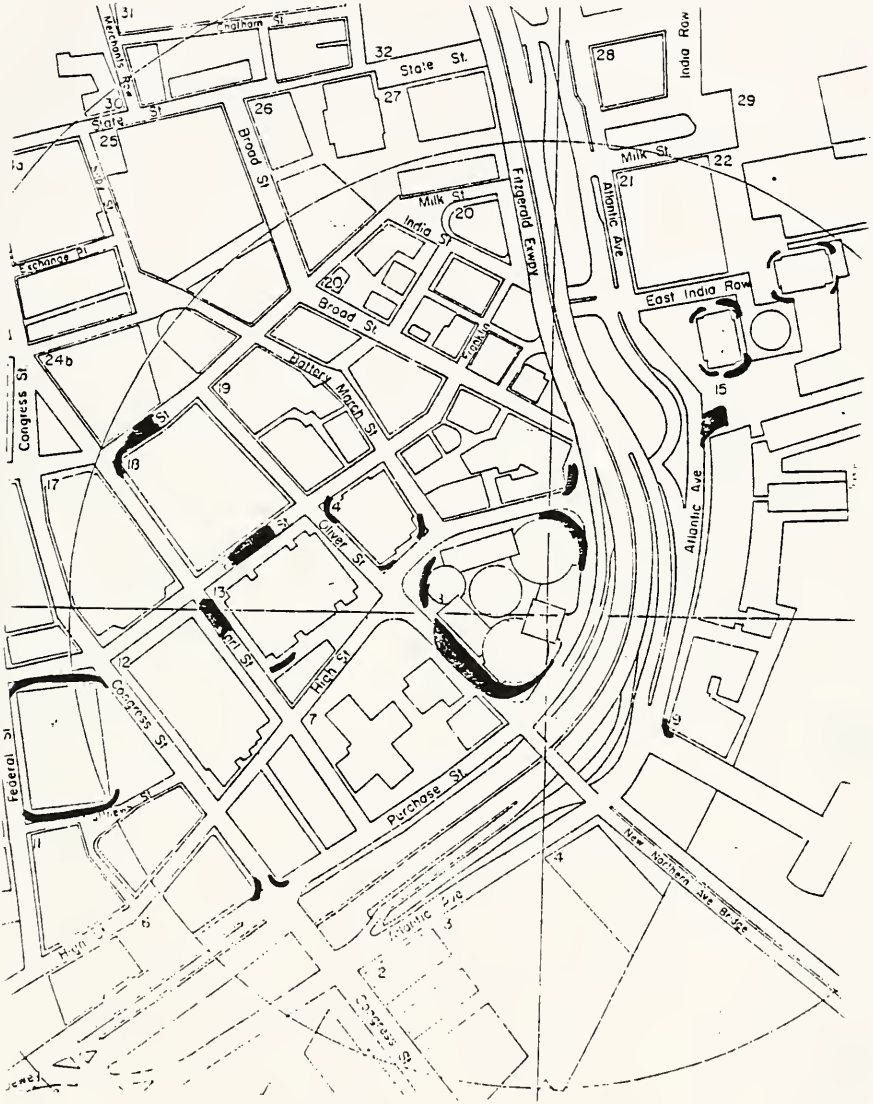
Location	Mean Wind Velocity* (mph)	Gust Wind Velocity** (mph)
LS-46	20	28
LS-45	17	25
LS-44	23	32
LS-47	23	31
LS-48	19	28
LS-49	19	28
LS-50	12	20
LS-21	9	16
LS-20	10	17
LS- 7	18	28
LS- 6	18	28

LS- 5	19	26
LS- 4	17	24
LS- 3	12	19

* Mean Wind Velocity exceeded one percent of the time expressed in miles-per-hour. Underlined numbers exceed BRA design criteria of 22 mph. Mean wind velocity.

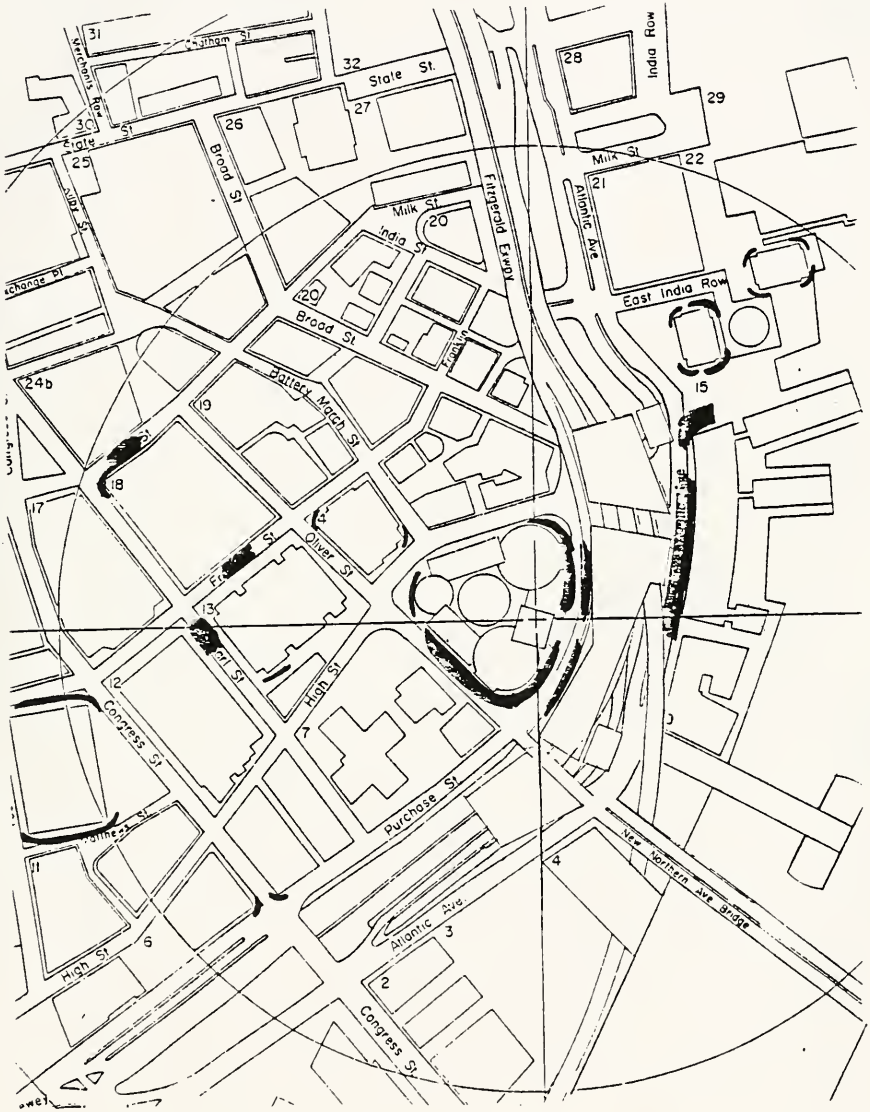
* Gust Wind Velocity (Mean + 1.5 RMS) exceeded one percent of the time expressed in miles per hour. Underlined numbers exceed BRA design criteria of 31 mph gust wind velocity.

Figure 9c High Velocity Areas for Configuration PH2



SOURCE: INTERNATIONAL PLACE FINAL EVIRONMENTAL PROJECT REPORT,1984

Figure 9e High Velocity Areas for Configuration PH2F



SOURCE: INTERNATIONAL PLACE FINAL EVIRONMENTAL PROJECT REPORT,1984

WIND ROSE PLOTTINGS

TABLE 2-1

Scale Applicable to:	P(AZ) (Probability that winds will originate from 3° azimuth segment shown)	P(U) (Probability that winds will exceed velocity when winds blow from direction shown)
1) inner ring	0.01 (1%)	10 mps (22.5 mph)
2) middle ring	0.02 (2%)	20 mps (45 mph)
3) outer ring	0.03 (3%)	30 mps (67.5 mph)

On these plots, the dashed line represents the probability that the wind will originate from a particular 3° azimuthal segment, and the solid contours are lines of equal probability-of-exceedance of various wind speeds to be expected when the winds blow from a given direction. On each "wind rose," the four solid contours start with the inner contour of P=0.1 (10% probability of exceedance) and progress outward to a contour of probability P=0.0001 (.01% probability of exceedance). For example, referring to the wind rose in Figure 2-2a (Annual Winds), there is an annualized probability of P=0.017 (1.7%) that the winds will blow from the 3° azimuthal segment centered on 270°), there is a 10% probability (P=0.1) that the mean wind speed at the 960 foot reference height will the mean wind speed will exceed 28 mps, and a .01% probability (P=0.0001) that the reference level mean wind speed will exceed 32.0 mps. When used in conjunction with wind tunnel measurements of pedestrian level wind velocities (which are usually normalized to form a ratio of ground level wind velocity-to-reference level mean wind velocity), an annualized (or seasonal) measurement of velocities which will be exceeded a given percentage of time can be derived.

The data in Figures 2-2a to 2-2b show that the critical wind directions for Boston are generally northwest, west and southwest, with important, but less significant winds coming from the south, northeast and north.

Winds from other directions must be considered inasmuch as occasional severe impacts may occur, but in terms of optimizing a massing scheme for the project, the directions identified above are predominant.

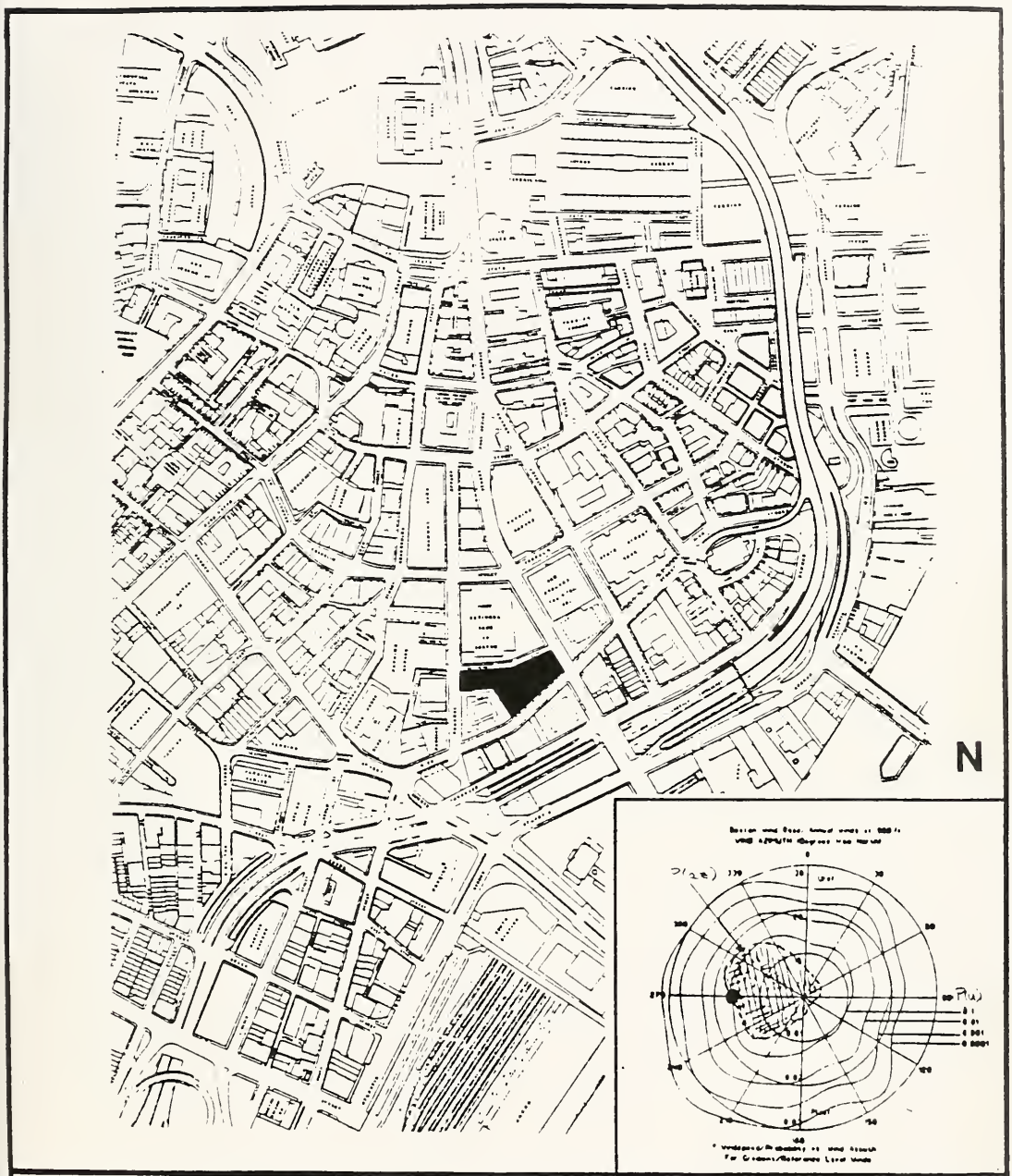


FIGURE 2-2a Annual Wind Rose

SOURCE: 150 FEDERAL STREET FINAL ENVIRONMENTAL PROJECT REPORT

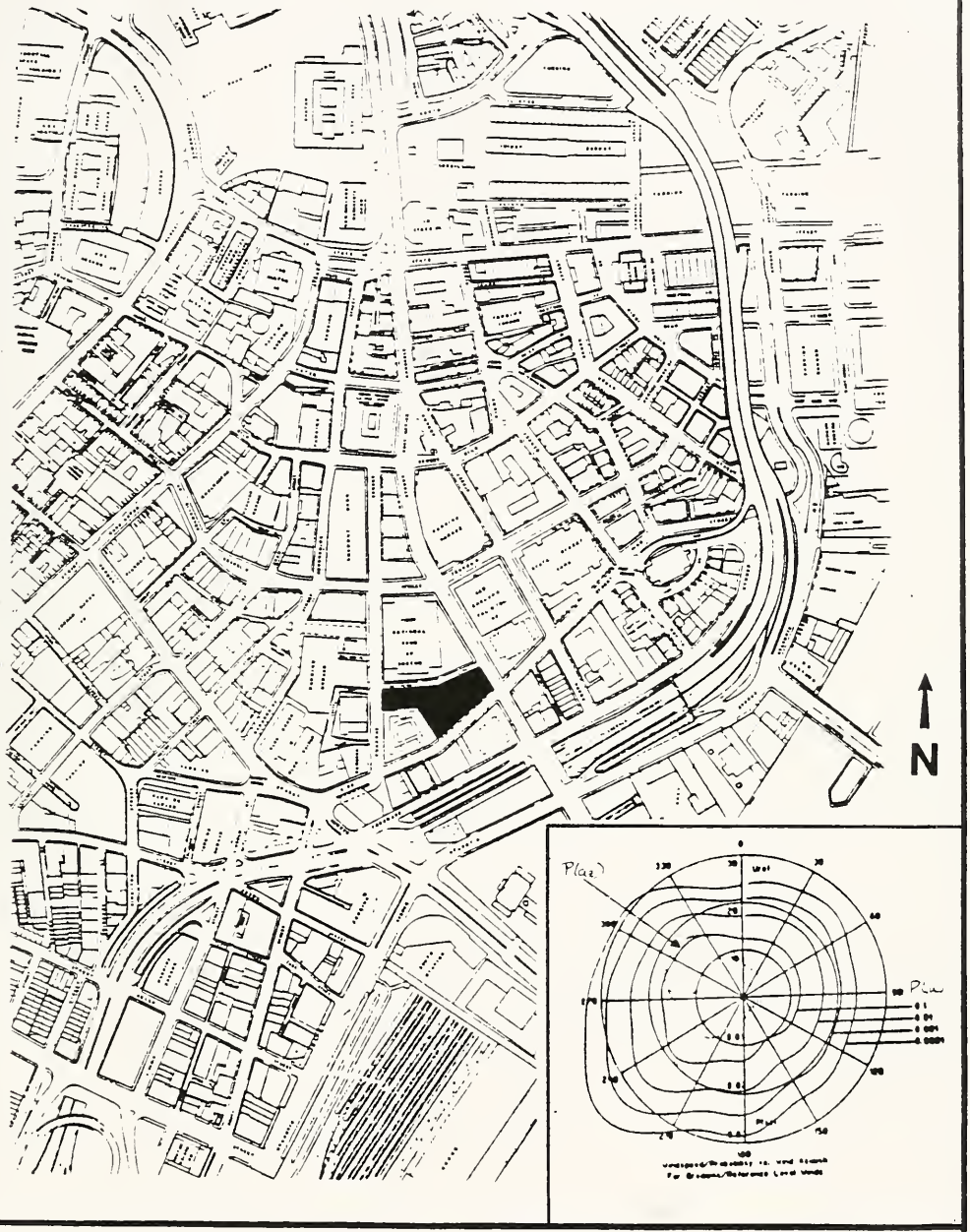


FIGURE 2-2b Spring Wind Rose

SOURCE: 150 FEDERAL STREET FINAL ENVIRONMENTAL PROJECT REPORT, 1985

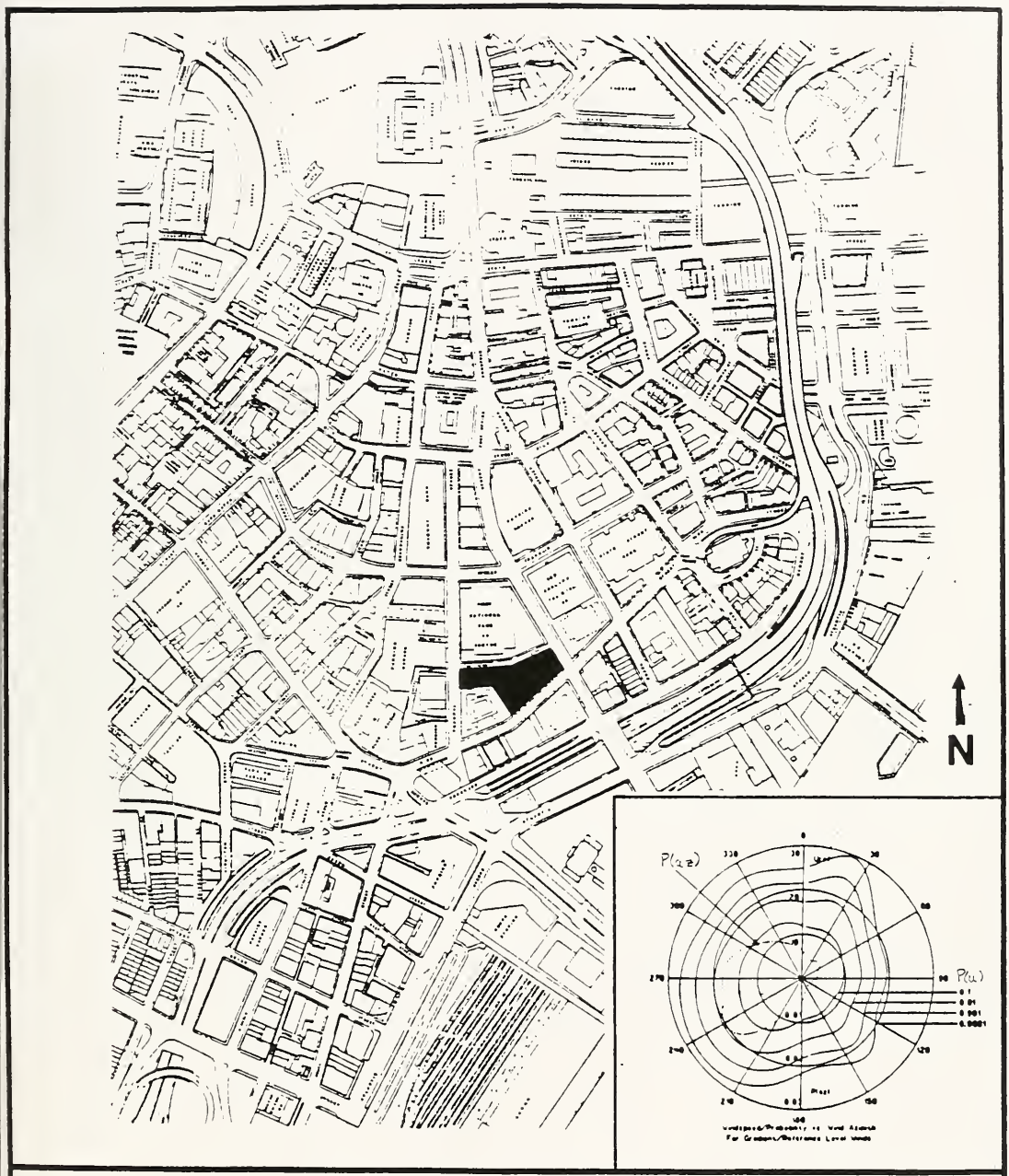


FIGURE 2-2c Summer Wind Rose

SOURCE: 150 FEDERAL STREET FINAL ENVIRONMENTAL PROJECT REPORT, 1985

FIGURE 2-2d Autumn Wind Rose

SOURCE: 150 FEDERAL STREET FINAL ENVIRONMENTAL PROJECT REPORT, 1985

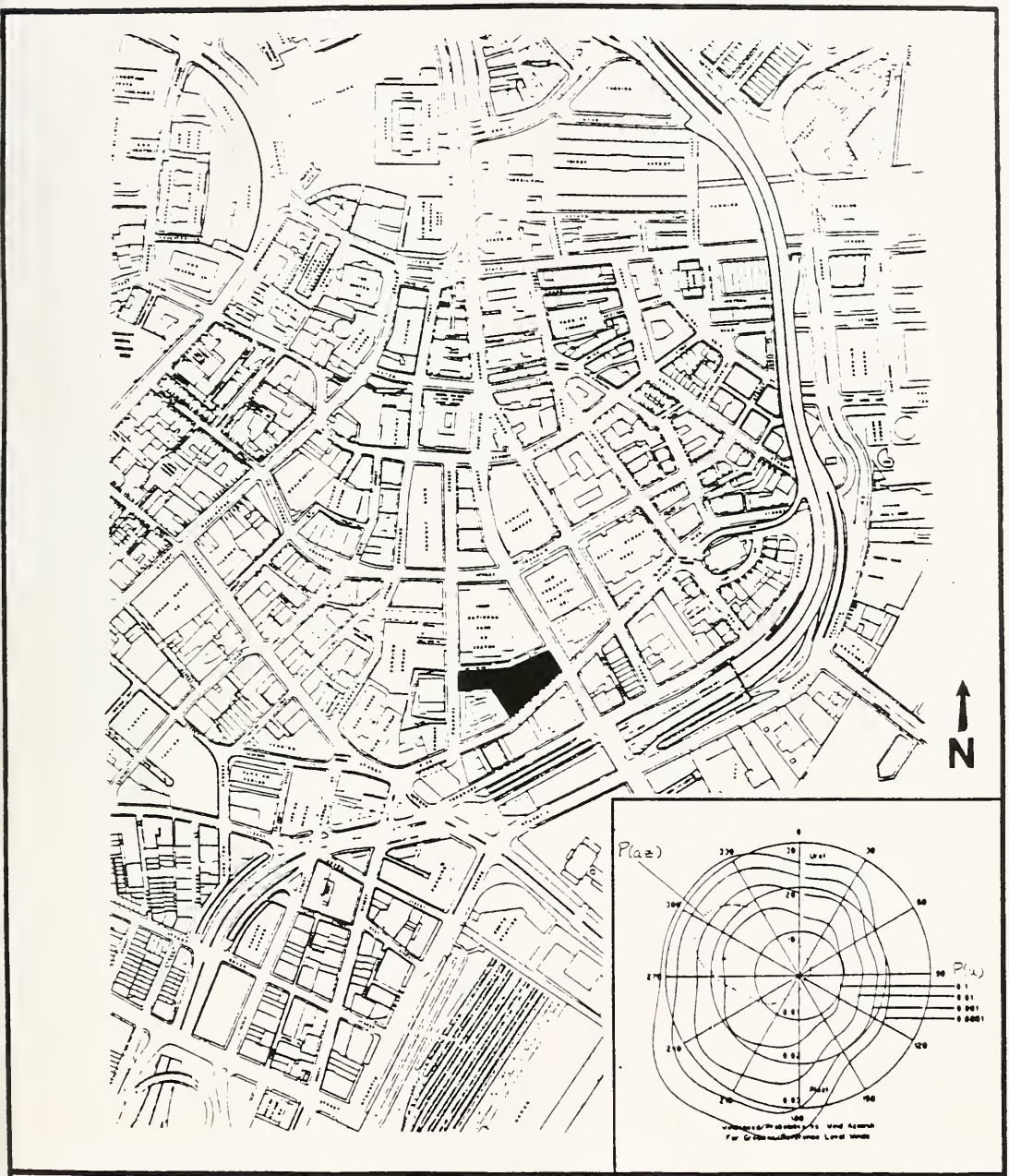


FIGURE 2-2e Winter Wind Rose

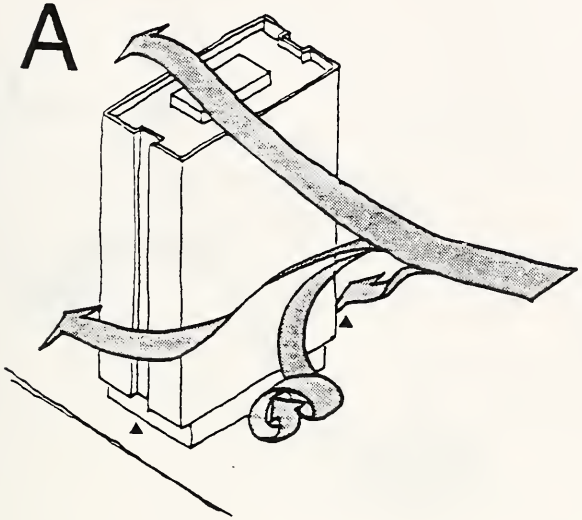
SOURCE: 150 FEDERAL STREET FINAL ENVIRONMENTAL PROJECT REPORT, 1

APPENDIX

WIND PROBLEM CHARACTERISTICS

PROBLEMS

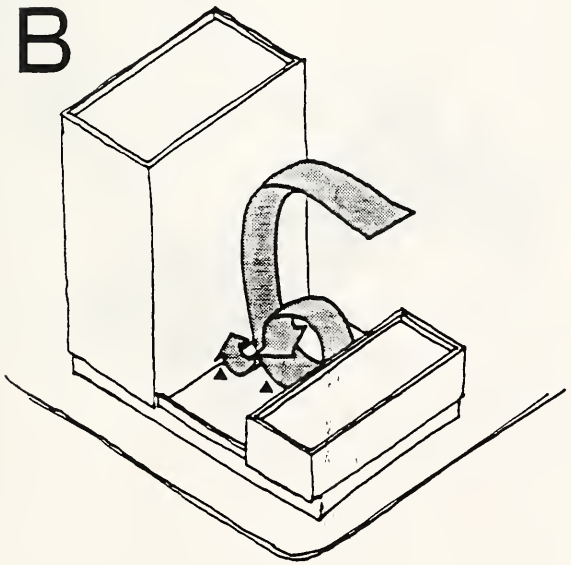
A



PROBLEM: STRONG UPPER LEVEL WINDS IMPINGE ON THE BUILDING FACE, DEFLECT DOWNWARDS AND ACCELERATE AROUND THE CORNERS OF THE BUILDING.

SOLUTIONS: 1, 3, 1 AND 3, OR 2 AND 3.

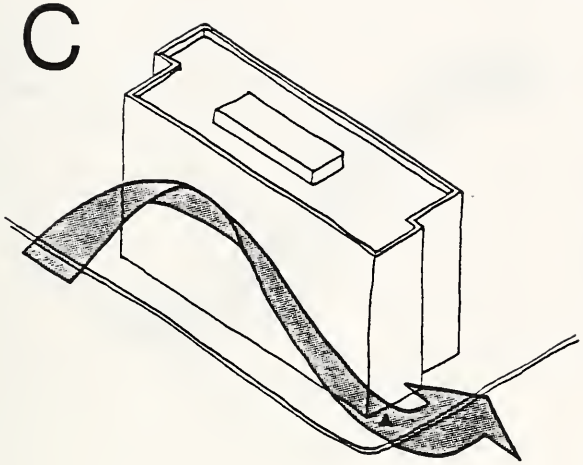
B



PROBLEM: LOCATING A LOW RISE BUILDING UPSTREAM OF A HIGH RISE CAN CAUSE MORE WIND TO BE DEFLECTED DOWN THE FACE OF THE BUILDING.

SOLUTIONS: 1, 3, 1 AND 3, OR 2 AND 3.

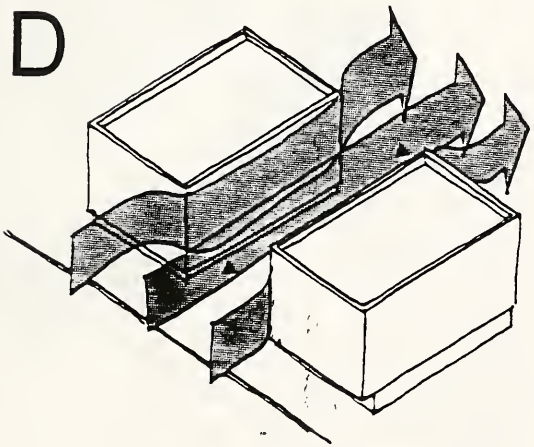
C



PROBLEM: WIND FLOWING AT AN ANGLE TO A LONG (AND TALL) BUILDING WILL BE CONCENTRATED AT THE DOWNWIND CORNER OF THE BUILDING. THE LONGER THE BUILDING, THE GREATER THE INCREASE IN PEDESTRIAN LEVEL WIND SPEED.

SOLUTIONS: 1, 1 AND 2, 1 AND 3, OR 2 AND 3.

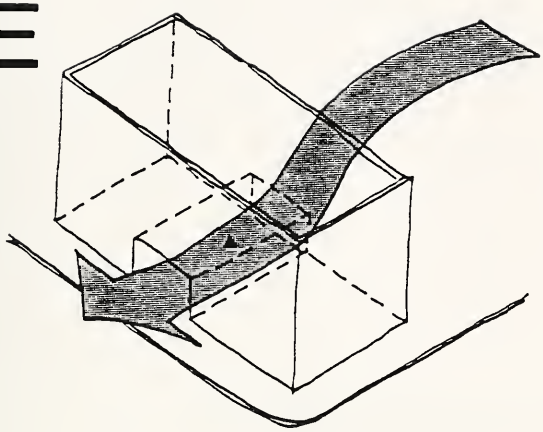
D



PROBLEM: THIS CREATES A VERY SEVERE PEDESTRIAN LEVEL WIND CONDITION. WIND CAN ALSO BE FUNNELED BY RELATIVELY LOW BUILDINGS.

SOLUTIONS: 1, 2, OR 1 AND 2.

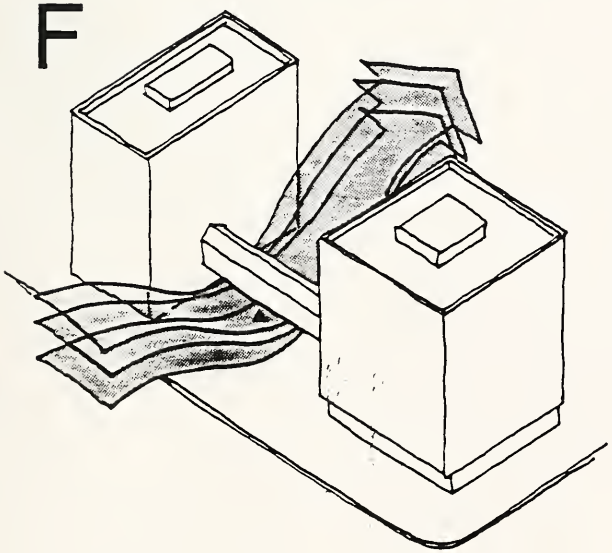
E



PROBLEM: AN OPEN PASSAGEWAY THROUGH A TALL BUILDING CREATES AN UNCOMFORTABLE CONDITION IN THE PASSAGEWAY AND REDUCES THE SHELTERED CONDITION BEHIND THE BUILDING. THIS EFFECT IS MAGNIFIED AS THE HEIGHT OF THE BUILDING IS INCREASED.

SOLUTIONS: 2, 3, OR 2 AND 3.

F



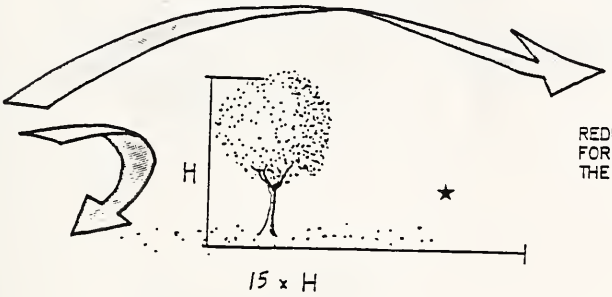
PROBLEM: ELEVATED WALKWAYS CAN FURTHER INCREASE ALREADY ACCELERATED WIND FLOWS.

SOLUTIONS: 1, 2, OR 1 AND 2.

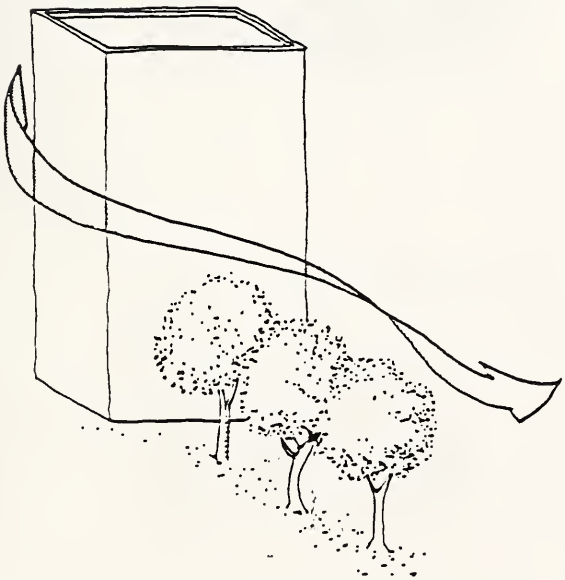
APPENDIX

WIND CONTROL SOLUTIONS FOR EXISTING PROBLEMS

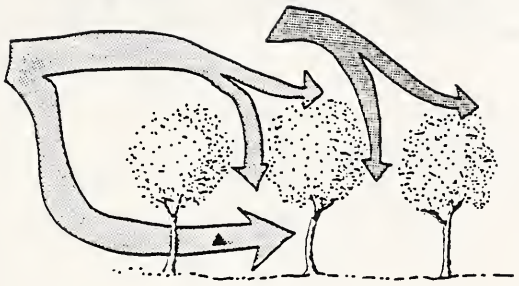
1. LANDSCAPING



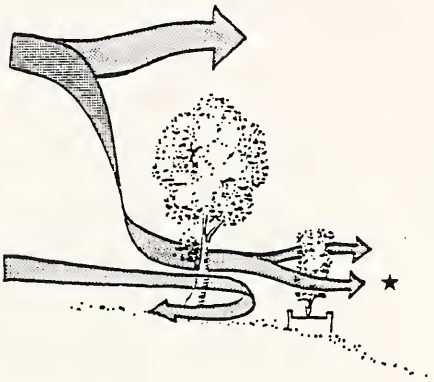
REDUCED VELOCITY AREA EXISTS FOR APPROXIMATELY 15 TIMES THE HEIGHT (H) OF THE TREES.



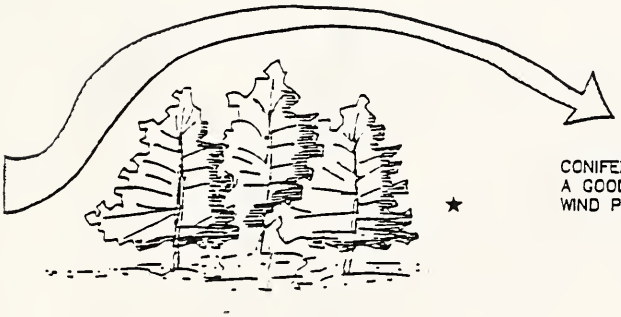
DOWNWACH FROM A BUILDING CAN SHORTEN THIS PROTECTED AREA.



DECIDUOUS TREES OFTEN DO NOT PROVIDE GROUND LEVEL PROTECTION, ONLY PROVIDE PROTECTION DURING THE SUMMER MONTHS, AND ARE GOOD FOR FORMING CANOPIES TO REDUCE DOWNWASH WIND FLOWS.

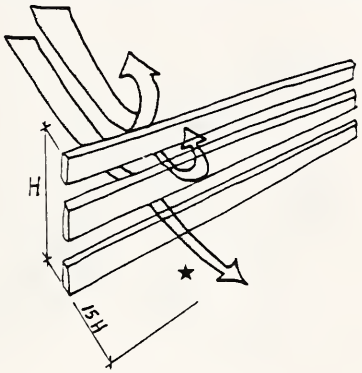


UNDERPLANTING WILL ASSIST DECIDUOUS TREES IN PROVIDING GROUND LEVEL PROTECTION.

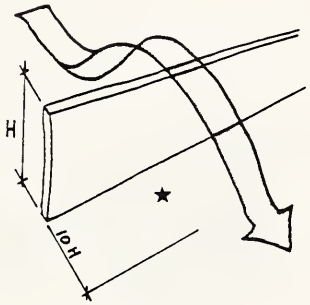


CONIFEROUS TREES ARE CONSIDERED A GOOD ALTERNATIVE FOR WINTER WIND PROTECTION.

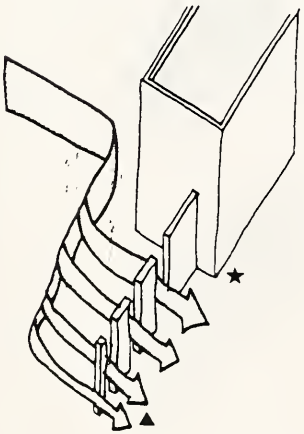
2. WINDSCREENS



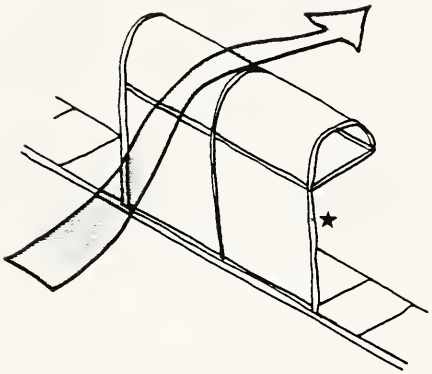
A 50% POROUS SCREEN PRODUCES A REDUCED VELOCITY AREA FOR 15 TIMES THE HEIGHT (H) OF THE SCREEN.



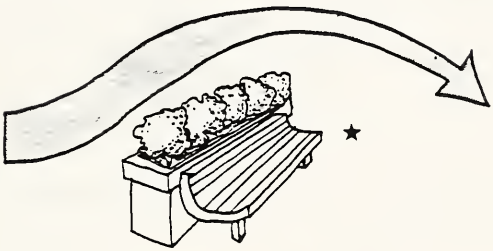
A SOLID FENCE PRODUCES A REDUCED VELOCITY AREA FOR 10 TIMES THE HEIGHT (H) OF THE FENCE.

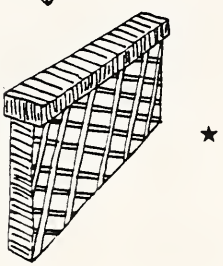


IF A WINDY AREA IS UNAVOIDABLE, INTRODUCE PEDESTRIANS TO THE HIGH WIND SPEED AREA GRADUALLY. FOR EXAMPLE, BAFFLES COULD BE USED TO BREAK UP THE WIND.



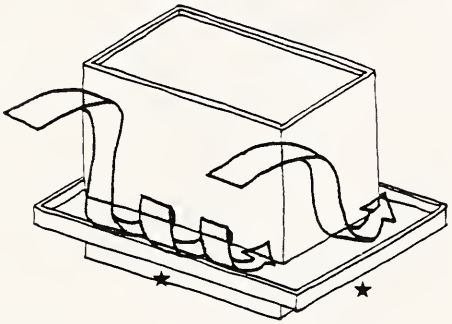
PARTIALLY ENCLOSED WALKWAYS MUST BE ORIENTED CONSIDERING THE PREVAILING WIND DIRECTIONS.



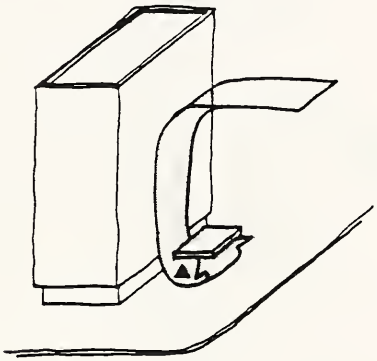


SMALL SCALE FEATURES SUCH AS BENCHES, PLANTERS, AND LATTICES SHOULD BE PLACED TO SHELTER PEDESTRIANS FROM ADVERSE WIND CONDITIONS.

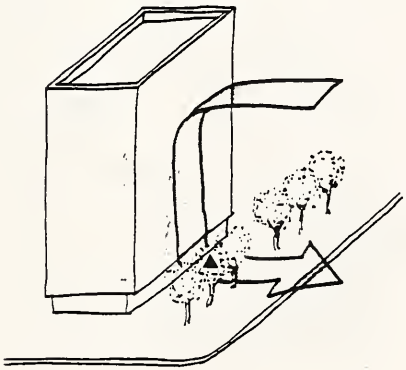
3. CANOPIES



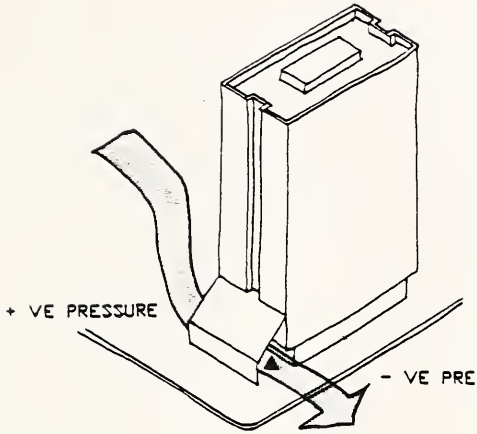
CANOPIES ARE BENEFICAL ON THE WINDWARD FACE AND SHOULD BE CONTINUED AROUND THE BUILDING. PARAPET WALLS WILL MAKE THE CANOPY MORE EFFECTIVE.



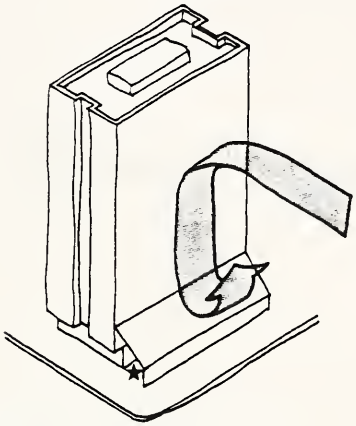
A CANOPY WHICH IS NOT TOUCHING A BUILDING IS INEFFECTIVE.



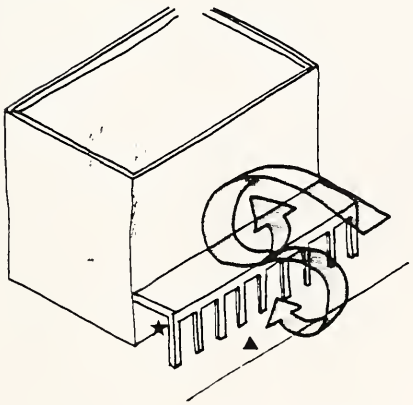
LANDSCAPING WHICH IS NOT TOUCHING A BUILDING IS ALSO INEFFECTIVE.



ENCLOSED PASSAGEWAYS SHOULD CONNECT AREAS OF EQUAL PRESSURES.



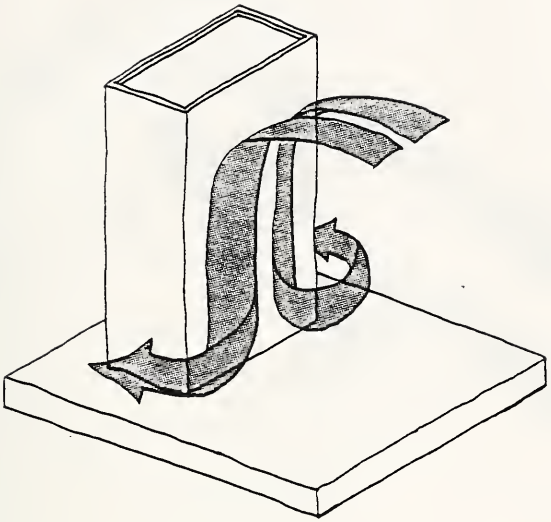
APPROXIMATELY EQUAL PRESSURES



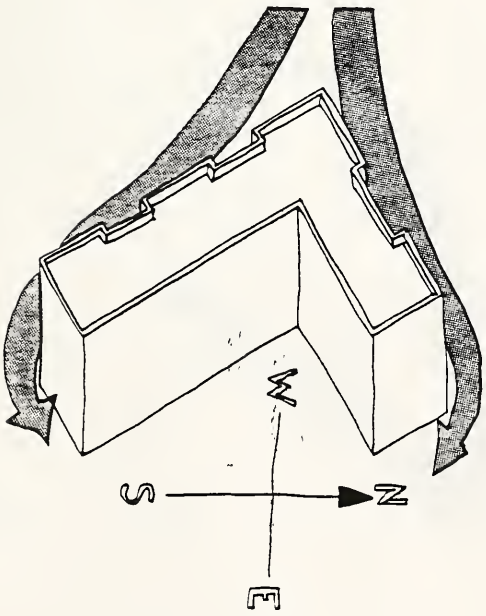
GIVE PEDESTRIANS A CHOICE OF CALM OR WINDY AREAS (BREEZES ARE WELCOME ON HOT DAYS).

APPENDIX

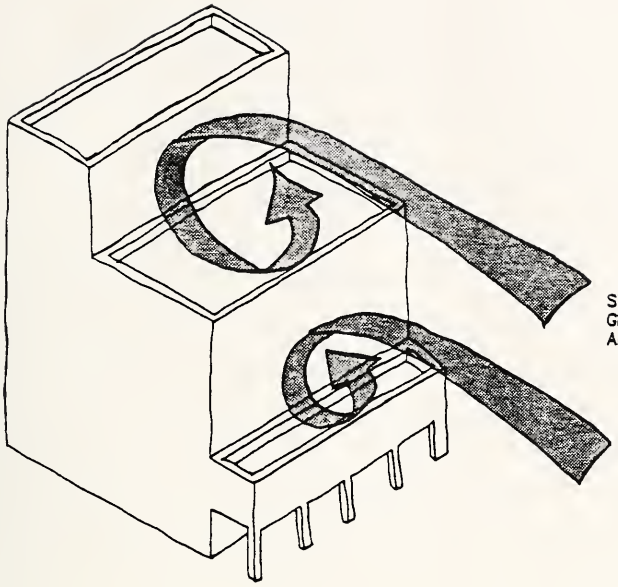
BUILDING MASS CONCEPTS FOR WIND CONTROL



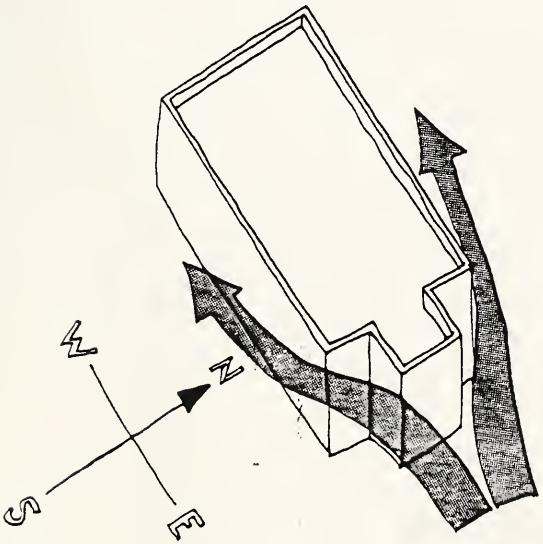
NON-PEDESTRIAN PODIUMS PROVIDE COMFORTABLE WALKWAYS AROUND TALL BUILDINGS.



BUILDINGS CAN BE USED AS WINDSCREENS BUT PEDESTRIAN AREAS SHOULD BE CAREFULLY SELECTED.



STEPPED BUILDINGS WILL GRADUALLY BREAK UP APPROACHING WIND FLOWS.



ALIGNMENT OF ELONGATED BUILDINGS WITH PREVAILING WINDS MINIMIZES IMPACT ON WIND FLOWS.
CUTTING/CHAMFERING WINDWARD BUILDING CORNERS FURTHER REDUCES IMPACT.

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